

**Estimated Entrainment of  
Striped Bass Eggs and Larvae at  
State Water Project and  
Central Valley Project Facilities in the  
Sacramento-San Joaquin Delta,  
1987**

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# ABSTRACT

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A striped bass (*Morone saxatilis*) egg and larval sampling program was conducted in the southern Delta near the intakes of the State Water Project and Central Valley Project during spring 1987. Estimates of striped bass eggs entrained were 2.1 million by the SWP and 6.8 million by the CVP. Estimates of striped bass larvae (fish less than 21 mm) entrained were 92.2 million by the SWP and 131.7 million by the CVP. Highest entrainment was for 3-6 mm larvae.

Striped bass yearling equivalent losses were 41,726 for the state facility and 68,479 for the federal facility.

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# INTRODUCTION

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Striped bass are entrained with water diverted by State Water Project and Central Valley Project pumping facilities in the southern Delta. Raquel (1987) estimated the numbers of striped bass eggs and larvae lost to these diversions by obtaining density estimates of eggs and larvae available to be entrained and the amount of water being diverted.

Density estimates were obtained by sampling with an egg and larval net in the channels immediately adjacent to each point of diversion. Total numbers of striped bass eggs and larvae entrained by the SWP were estimated at 441.1 million in 1985 and 51.9 million in 1986 (Raquel, 1987). For the CVP, the estimates were 35.5 million in 1985 and 47.8 million in 1986.

Additional stations near the diversions were also sampled to obtain information on the source of the eggs and larvae, but those sample areas are not dealt with in this report.

## MATERIALS AND METHODS

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An egg and larval survey was conducted from April to July 1987, at seven locations in the southern Delta (Figure 1). Station 97 was deleted and replaced by new Station 94 because of the proximity to Station 97 and to lessen the effect of tidal sloshing.

Another new station (93), in Old River about 4 km upstream of the CVP, was added in 1987 because the former stations would not effectively sample eggs and larvae spawned upstream of the Federal facility. This assumes that most, if not all of, Old River water is diverted directly to the Tracy Fish Facility.

Station numbers and their locations were:

91 (ROLD 38)	About 0.5 mile upstream of the Highway 4 bridge on Old River
92 (DHWST 0)	On West Canal about 650 feet downstream of Clifton Court Forebay intake
93 (ROLD 52)	On Old River about 2.5 miles upstream of Tracy Fish Facility
94 CHGRL 3)	On Grant Line Canal about 1.5 miles upstream of its confluence with Old River
95 (CHNRT 0)	On North Canal about 300 feet downstream of its confluence with Old River (where the canal becomes straight)
96 (ROLD 47)	On Old River about 1,300 feet downstream of the intake to the CVP
98 (CHGRL 11)	On Grant Line Canal near the mouth of Salmon Slough

Samples were taken at each station every other day from April 13 to July 10. Samples were taken by making a single 10-minute oblique tow at each station with an egg and larval net mounted on a ski frame. A digital flowmeter was used to measure water flow through the net so cubic meters of water sampled could be computed. Raquel (1987) presents a detailed account of materials, methods, and laboratory procedures.

Surface water temperature, water transparency (secchi disc), and surface electrical conductivity were measured at each sample site. When the electrical conductivity meter was calibrated at the end of the sampling season, it was discovered that the meter was out of calibration, especially at the higher ranges of conductivity. However, the low readings measured should be reasonably accurate.

Daily inflow to Clifton Court Forebay for the SWP and daily exports from the CVP, both in acre-feet, for April through July obtained from daily operation summaries for each facility (DWR, 1987; DFG, Bay-Delta Project, unpublished data) are presented in Appendix A.

To estimate density of striped bass eggs and larvae entrained, densities at sampling stations immediately in line with the intake of each facility (Station 96, SWP; Station 92, CVP) were used. Data were separated into size groups: eggs and 3-6 mm, 7-10 mm, 11-14 mm, 15-18 mm, and 19-20 mm larvae. Densities (eggs or larvae per cubic meter) for each size group were calculated for each sampling station, by day. Daily inflow to Clifton Court Forebay (SWP) and daily export by the CVP were then multiplied by the appropriate density of eggs and larvae. For days when no samples were taken, the previous day's densities were used to calculate entrainment.

Yearling equivalent losses were estimated based on survival rates calculated by Ecological Analysts (1981).

## RESULTS

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Total estimated entrainment of striped bass eggs and larvae (fish less than 21 mm long) were 94.3 million for the SWP and 138.5 million for the CVP. During this period, SWP inflow totaled 489,396 acre-feet, and CVP exports totaled 706,486 acre-feet.

### State Water Project

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Bimonthly average density of striped bass eggs near the intake to the SWP was highest during April 16-30 (0.01485 eggs/m<sup>3</sup>) (Table 1). No eggs were observed after May 19. Bimonthly average density of striped bass larvae was highest during May 1-15. Average density of all larvae per cubic meter during this period was 0.1662.

Entrainment of striped bass eggs and larvae by the SWP was estimated at 94.3 million (Table 2). Entrainment was highest for the 3-6 mm larvae group (47.3 million).

Surface water temperature, water transparency (secchi disc), and surface electrical conductivity at the sampling station near the intake were averaged on a bimonthly basis (Table 3).

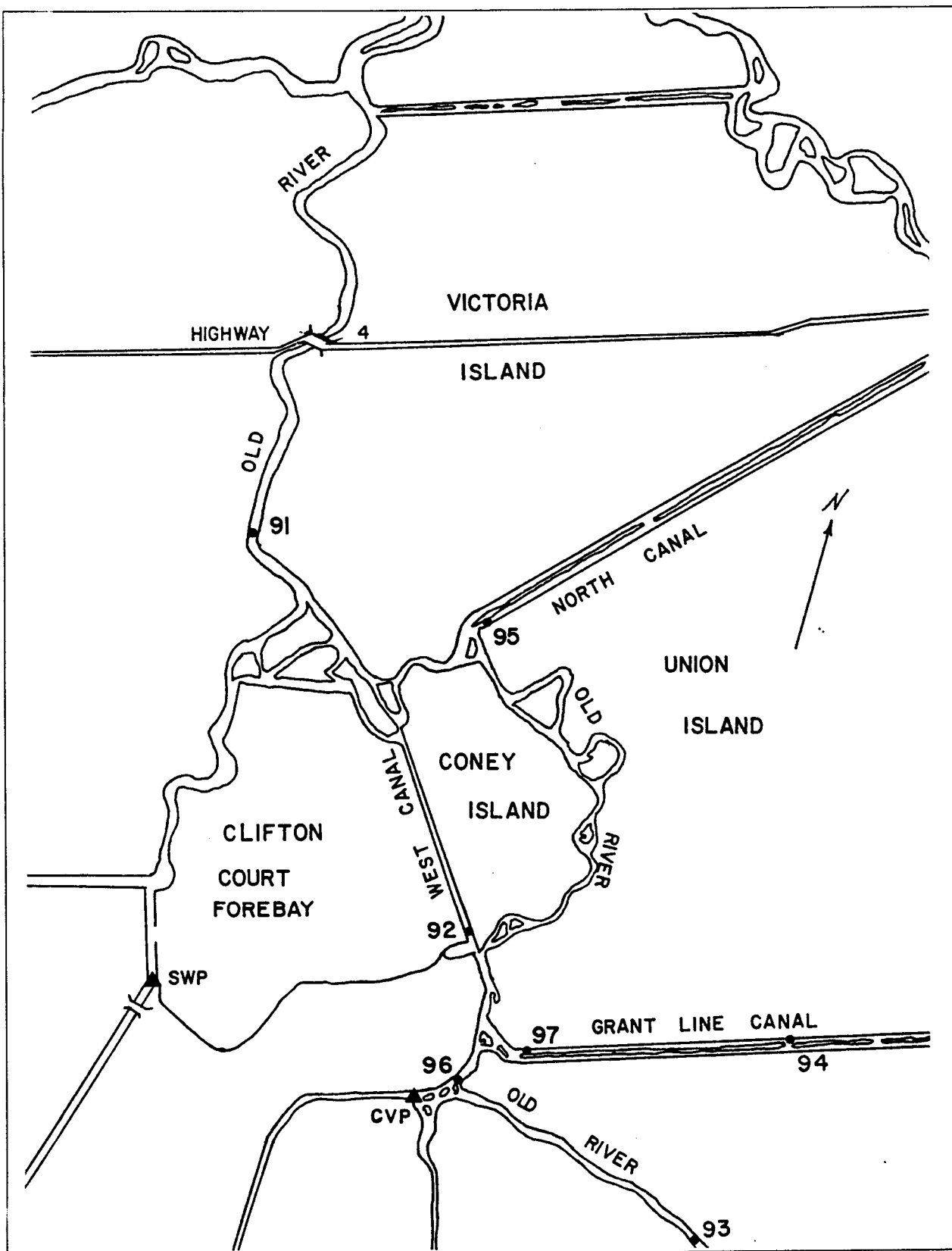


Figure 1  
SOUTHERN DELTA EGG AND LARVAL SAMPLING STATIONS AND  
STATE WATER PROJECT AND CENTRAL VALLEY PROJECT DIVERSION SITES

Table 1  
STRIPED BASS EGG AND LARVAL AVERAGE DENSITY AT THE  
STATE WATER PROJECT INTAKE,  
1987  
(Fish per Cubic Meter)

	Eggs	3-6 mm	Size Groups		15-18 mm	19-20 mm
			7-10 mm	11-14 mm		
April 1-15	0.00990	0.01599	0	0	0	0
April 16-30	0.01485	0.18498	0.05643	0.00096	0	0
May 1-15	0.00267	0.26926	0.35086	0.04163	0.00324	0
May 16-31	0.00125	0.01913	0.02609	0.02515	0.00524	0
June 1-15	0	0.00965	0.02135	0.01103	0.00227	0.00057
June 16-30	0	0.00777	0.01325	0.00115	0.00120	0
July 1-15	0	0	0.00076	0	0.00076	0

Table 2  
STRIPED BASS EGG AND LARVAL ENTRAINMENT ESTIMATES FOR THE  
STATE WATER PROJECT INTAKE,  
1987

	Eggs	3-6 mm	Size Groups		15-18 mm	19-20 mm
			7-10 mm	11-14 mm		
April 1-15	217,105	382,409	0	0	0	0
April 16-30	1,485,989	19,025,702	5,804,062	72,789	0	0
May 1-15	276,285	24,807,668	26,616,500	3,041,846	213,830	0
May 16-31	105,414	1,749,903	2,220,499	1,925,339	512,823	0
June 1-15	0	592,376	1,473,853	882,657	259,889	0
June 16-30	0	706,085	1,508,766	109,736	163,443	0
July 1-15	0	0	79,691	0	79,691	0
Total	2,084,793	47,264,143	37,703,371	6,032,366	1,229,676	0
Grand Total						94,314,349

Table 3  
BIMONTHLY AVERAGE OF ENVIRONMENTAL PARAMETERS  
AND EXPORT RATES NEAR THE  
STATE WATER PROJECT INTAKE,  
APRIL 1 THROUGH JULY 10, 1987

	EC ( $\mu$ mhos)	Secchi (cm)	Temperature (°F)	Export (acre-feet)
April 1-15	399	65	64	5215
April 16-30	379	49	66	5007
May 1-15	374	47	72	4814
May 16-31	434	35	69	3879
June 1-15	450	40	73	3381
June 16-30	462	45	73	4773
July 1-10	486	48	73	7948

## Central Valley Project

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Bimonthly average density of striped bass eggs near the intake to the CVP was highest during April 1-15 (0.03474 eggs/m<sup>3</sup>) (Table 4). Bimonthly average density of striped bass larvae was highest during April 16-30 for the 3-6 mm group (0.25474 fish/m<sup>3</sup>) and during May 1-15 for the 7-10 mm and 11-14 mm groups. Average density of all larvae during May 1-15 was 0.13497 larvae/m<sup>3</sup>.

Entrainment of striped bass eggs and larvae by the CVP was estimated at 138.5 million (Table 5). Entrainment was highest for the 3-6 mm larvae group (73.5 million).

Surface water temperature, water transparency (secchi disc), and surface electrical conductivity at the sampling station near the intake were averaged on a bimonthly basis (Table 6).

## Yearling Equivalent Losses

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Entrainment losses for striped bass eggs and larvae were converted to an equivalent number of one-year-old fish. Yearling equivalent losses were estimated at 41,726 at the SWP facility and 68,479 at the CVP facility (Table 7). For both facilities, highest yearling equivalent losses were for the 11-14 mm group.

## DISCUSSION

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In spring 1987, loss of striped bass eggs and larvae was estimated based on direct measurement of densities of eggs and larvae at points near the diversions and the volume of water being exported during the survey. Highest densities of eggs and larvae for the last three years (*Raquel, 1987*) were:

	Eggs/m <sup>3</sup>		Larvae/m <sup>3</sup>	
	SWP	CVP	SWP	CVP
1987	0.01485	0.0347	0.3509	0.2705
1986	0.0277	0.0628	0.1561	0.0998
1985	0.6064	0.4833	1.0399	0.8754

In 1987, peak density of eggs near the SWP was during the second half of April; for the CVP, the peak was during the first half of April. In contrast, in 1985 and 1986 the peak was during the first half of May for the SWP; for the CVP the peak was during the first half of May in 1985 and during the second half of May in 1986.

Peak density of larvae in 1987 was during the first half of May for both the SWP and CVP; during both 1985 and 1986, the peak was during the second half of May for both facilities.

The lower egg densities in 1987 suggest that a large portion of striped bass spawned before the survey started and/or that spawning occurred farther from the SWP and CVP intakes, giving the eggs more time to develop and hatch before reaching the sampling stations.



Table 4  
STRIPED BASS EGG AND LARVAL AVERAGE DENSITY AT THE  
CENTRAL VALLEY PROJECT INTAKE,  
1987  
(Fish per Cubic Meter)

	Eggs	3-6 mm	Size Groups			19-20 mm
			7-10 mm	11-14 mm	15-18 mm	
April 1-15	0.03474	0.00556	0	0	0	0
April 16-30	0.01603	0.25474	0.03210	0	0	0
May 1-15	0.02592	0.22043	0.27054	0.04478	0.00412	0.00053
May 16-31	0	0.02180	0.03970	0.02620	0.00837	0.00106
June 1-15	0	0.01151	0.01791	0.00949	0.00352	0
June 16-30	0	0.01037	0.01432	0.00274	0	0.00055
July 1-15	0	0.00082	0.00127	0	0	0

Table 5  
STRIPED BASS EGG AND LARVAL ENTRAINMENT ESTIMATES FOR THE  
CENTRAL VALLEY PROJECT INTAKE,  
1987

	Eggs	3-6 mm	Size Groups			19-20 mm
			7-10 mm	11-14 mm	15-18 mm	
April 1-15	1,158,419	185,347	0	0	0	0
April 16-30	2,677,561	42,630,816	5,376,264	0	0	0
May 1-15	2,999,796	25,329,521	31,620,150	5,517,454	527,846	69,581
May 16-31	0	2,836,988	5,270,705	3,114,451	1,022,756	163,824
June 1-15	0	1,369,541	2,117,356	1,115,767	415,672	0
June 16-30	0	1,036,849	1,400,455	260,783	0	50,780
July 1-15	0	83,100	135,804	0	0	0
Total	6,835,776	73,472,162	45,920,734	10,008,455	1,966,274	284,184
Grand Total						138,487,585

Table 6  
BIMONTHLY AVERAGE OF ENVIRONMENTAL PARAMETERS  
AND EXPORT RATES NEAR THE  
CENTRAL VALLEY PROJECT INTAKE,  
APRIL 1 THROUGH JULY 10, 1987

	EC ( $\mu$ mhos)	Secchi (cm)	Temperature (°F)	Export (acre-feet)
April 1-15	562	54	65	8176
April 16-30	393	44	66	9036
May 1-15	396	43	72	6582
May 16-31	380	36	68	5370
June 1-15	422	42	72	6402
June 16-30	485	37	72	5491
July 1-10	447	36	72	8528

Table 7  
STRIPED BASS YEARLING EQUIVALENT LOSS AT  
STATE WATER PROJECT AND  
CENTRAL VALLEY PROJECT EXPORT FACILITIES,  
1987\*

Size Group	Survival Rate to Age 1**	SWP	CVP
Eggs	0.000047	98	321
3-6 mm	0.000124	5,861	9,111
7-10 mm	0.000338	12,744	15,521
11-14 mm	0.002509	15,135	25,111
15-18 mm	0.006415	7,888	12,614
19-20 mm	0.020414	0	5,801
Total		41,726	68,479

\* Based on densities near the intakes and water exports, April 13 through July 10, 1987.

\*\* Survival rates to age 1 calculated by Ecological Analysts (1981).  
Egg survival rate was estimated by calculating potential number of eggs spawned compared to estimated number of age 1 fish in the estuary.

Estimated entrainment of eggs for the SWP in 1987 was about 41 times greater than in 1985 and 1.8 times greater than in 1986. For the CVP, entrainment in 1987 was about 12.5 times greater than in 1985 and 1.4 times greater than in 1986.

Average densities of larvae of all sizes were similar for the SWP and CVP. However, the CVP entrained about 47 percent more eggs and larvae, because it exported about 44 percent more water than the SWP.

Combined SWP and CVP yearling equivalent losses in 1987 (110,205) were higher than in 1985 and 1986 (*Raquel, 1987*). This difference is due to the higher densities in the larger size groups for both facilities and to higher exports by the CVP in 1987.

## **REFERENCES**

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Appendix A  
Daily SWP Inflow and CVP Export,  
April 1 through July 10, 1987  
(Acre-Feet)

Day	State Water Project Inflow				Central Valley Project Exports			
	April	May	June	July	April	May	June	July
1	5,059	6,912	2,765	3,967	7,536	6,013	5,795	8,901
2	5,446	3,948	4,941	7,934	8,166	6,333	6,285	8,497
3	6,113	4,173	4,945	8,492	8,240	6,002	6,624	8,547
4	5,393	4,226	4,945	7,152	8,215	6,014	6,458	8,962
5	5,168	5,501	3,787	8,331	7,864	6,018	6,435	8,850
6	5,214	6,337	2,371	7,285	8,131	6,026	6,412	8,387
7	6,449	4,949	1,365	9,719	8,061	6,033	6,475	7,765
8	5,982	2,946	1,370	9,952	8,066	7,361	6,446	7,790
9	5,905	2,005	1,536	8,716	8,002	7,724	6,542	8,550
10	3,560	1,998	2,577	7,934	8,001	6,430	6,378	9,030
11	1,944	5,007	4,947		8,009	5,936	6,439	
12	1,874	5,707	3,695		7,956	6,441	6,468	
13	5,944	6,555	3,956		8,511	6,555	6,447	
14	8,251	5,997	3,957		8,873	7,721	6,454	
15	5,929	5,950	3,561		9,010	8,116	6,369	
16	4,946	6,546	5,359		9,015	8,138	6,154	
17	4,956	7,041	4,944		9,050	8,168	6,329	
18	3,379	6,942	7,334		8,982	8,043	6,318	
19	4,641	6,545	7,330		9,055	8,151	5,449	
20	6,283	1,983	6,337		8,880	7,135	5,169	
21	3,968	3,552	6,933		9,145	5,251	5,179	
22	7,199	3,356	5,946		8,747	4,808	5,175	
23	6,521	3,275	3,843		9,215	4,980	5,190	
24	5,925	3,145	3,838		9,085	5,051	5,198	
25	6,338	3,366	4,562		8,742	3,800	5,209	
26	4,938	3,056	3,769		9,159	3,395	5,091	
27	6,927	2,762	2,480		9,083	3,380	4,870	
28	4,145	2,922	2,478		9,080	3,400	4,988	
29	2,957	3,308	3,064		9,131	3,385	5,727	
30	1,983	2,076	3,372		9,165	4,006	6,315	
31		2,184				4,830		
Total	153,337	134,270	122,307	79,482	258,175	184,644	178,388	85,279
Grand Total				489,396				706,486